How many screws are necessary for subtalar fusion? A retrospective study

Wirth, Stephan H ; Viehöfer, Arnd ; Fritz, Yannick ; Zimmermann, Stefan M ; Rigling, Dominic ; Urbanschitz, Lukas

Abstract: BACKGROUND Biomechanical studies have shown a higher compressive force and higher torsional stiffness for fixation with three screws compared to two screws. However, clinical data to compare these fixation techniques is still lacking. METHODS A retrospective analysis of 113 patients was performed, who underwent isolated subtalar fusion between January 2006 and April 2018. RESULTS Revision arthrodesis was required in 8% (n=6/36) for 3-screw-fixation and 38% (n=35/77) for 2-screw-fixation. For 3-screw-fixation, non-union, was observed in 14% (n=5/36) compared to 35% (n=27/77) in 2-screw fixation. Non-union (p=.025) and revision arthrodesis (p=.034) were significantly more frequent in patients with 2 screws. A body mass index 30kg/m^2 (p=.04, OR=2.6,95%CI:1.1-6.3), prior ankle-fusion (p=.017,OR=4.4,95%CI:1.3-14.5) and diabetes mellitus (p=.04,OR=4.9,95%CI:1.1-17.8) were associated with a higher rate of revision arthrodesis. CONCLUSIONS Our findings suggest that successful subtalar fusion is more reliably achieved with use of three screws. However, future prospective studies will be necessary to further specify this recommendation.

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How Many Screws are Necessary for Subtalar Fusion? A Retrospective Study

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HIGHLIGHTS

- For subtalar arthrodesis, 3-screw-fixation has lower revision arthrodesis and non-union rate compared to 2-screw-fixation
- Prior ankle fusion, BMI ≥30kg/m^2 and diabetes mellitus are relevant risk factors for revision arthrodesis
- This study confirms the clinical relevance of previous in vitro findings for subtalar arthrodesis

ABSTRACT

BACKGROUND:

Biomechanical studies have shown a higher compressive force and higher torsional stiffness for fixation with three screws compared to two screws. However, clinical data to compare these fixation techniques is still lacking.

METHODS:

A retrospective analysis of 113 patients was performed, who underwent isolated subtalar fusion between January 2006 and April 2018.

RESULTS:

Revision arthrodesis was required in 8% (n=6/36) for 3-screw-fixation and 38% (n=35/77) for 2-screw-fixation. For 3-screw-fixation, non-union, was observed in 14% (n=5/36) compared to 35% (n=27/77) in 2-screw fixation. Non-union (p=.025) and revision arthrodesis (p=.034) were significantly more frequent in patients with 2 screws. A body mass index $\geq 30 kg/m^2$ (p=.04, OR=2.6,95%CI:1.1-6.3), prior ankle-fusion (p=.017,OR=4.4,95%CI:1.3-14.5) and diabetes mellitus (p=.04,OR=4.9,95%CI:1.1-17.8) were associated with a higher rate of revision arthrodesis.

CONCLUSIONS:

Our findings suggest that successful subtalar fusion is more reliably achieved with use of three screws. However, future prospective studies will be necessary to further specify this recommendation.

Keywords: Subtalar, Arthrodesis, Screws, Fusion, Revision

INTRODUCTION

The subtalar joint consists of an anterior, posterior and medial joint facet, which allows for in- and eversion of the foot. Several pathologies may lead to pain originating from the subtalar joint, including primary arthritis, posttraumatic arthritis, congenital or acquired deformities, instability, tarsal coalition or inflammatory diseases. Once conservative treatment has failed, subtalar fusion is a common treatment which offers improved pain relief for weightbearing activities[1].

In the past, subtalar fusion was most regularly performed simultaneously with talonavicular (double arthrodesis) or talonavicular and calcaneocuboid fusion (triple arthrodesis). However, as the mobility of the talonavicular joint has a major impact on hindfoot function, fusion of the subtalar joint alone may have less adverse effects[2,3]. Furthermore, the development of secondary osteoarthritis in adjacent joints may be less common[4].

A variety of surgical techniques, both open and arthroscopic, have been described with varying results[5]. Common complications include wound infections, sensory deficits or persisting pain. Non-union is a severe, although less common, complication after subtalar fusion and may require recurrent surgery. The rate of non-union varies among authors between 0 –46%[6–9]. Described risk factors for non-union are history of smoking or alcoholism, diabetes, coexisting psychiatric diseases, prior ankle-fusion, persisting infections or revision surgery[10,11].

Biomechanical studies have demonstrated that using 3 screws rather than 2 can provide a significantly higher amount of compressive force as well as torsional stiffness and may therefore prevent development of non-union[12,13]. To this date however, there is no clinical data to support these in-vitro findings regarding the number of screws used in

open subtalar fusion and their contribution to the rate of non-union. The aim of the present study was to investigate, whether the use of three screws leads to higher fusion rates compared to two screws.

MATERIAL AND METHODS

Following approval of the local ethics committee, we retrospectively analyzed all patients who underwent isolated subtalar fusion with 2 or 3 screws between January 2006 and April 2018 (image 1). Patients below the age of 18 years were excluded from this study. The number of utilized screws was randomly distributed between both groups due to the surgeon's preference. The influence of the number of utilized screws on the incidence of non-union and revision arthrodesis (as primary endpoints) was investigated. As secondary endpoints, we defined need of screw removal, the influence of recently identified risk factors[7,14] for non-union following subtalar fusion, including patient age, BMI≥30kg/m^2, smoking, diabetes mellitus, prior surgery of the foot and ankle, and more specifically prior ankle fusion. Fusion of the subtalar joint was judged on plain x-rays and computed tomography imaging, as any size of bone bridging between the calcaneus und the talus was considered as fusion independent of the location. Non-union was defined as failure of bone consolidation at 12 months after surgery. Patients who did not reach one of the end-points (successful fusion, non-union after 12 months or revision) were excluded from statistical analysis. Study groups did not undergo matching.

Descriptive analysis was used to summarize the baseline characteristics. Categorical variables were depicted as frequencies and percentages, and continuous variables were listed as means and standard deviations. Fisher's exact test and Chi²-Test was performed for comparison of dichotomous variables, and a Mann-Whitney-Test for comparison of independent metric variables. A p value of less than 0.05 was considered significant. Statistical analysis was performed on IBM SPSS Statistics version 23 (2015, USA).

RESULTS

Between January 2006 and April 2018, 131 patients underwent isolated subtalar fusion with 2 or 3 screws at our clinic. Of those patients, 113 reached at least one of the end points (fusion, revision or non-union). The only significant difference in the patient characteristics was a higher rate of active smokers in patients where 3 screws were used. With the numbers available, no other significant difference could be detected. (Table 1).

Most frequently subtalar fusion was indicated due to posttraumatic osteoarthritis. Overall, 56 (50%) patients underwent subtalar fusion for posttraumatic changes, 42 (37%) for primary osteoarthritis, 13 (12%) for subtalar coalition and 2 (2%) for postinfectious joint-destruction. Distribution between the groups can be seen in Table 1.

51% of all patients had undergone prior surgery, whereby osteosynthesis of a calcaneus fracture was most common (n=26). The other prior surgeries were highly heterogeneous, including prior ankle fusion (n=13), arthroscopic surgery (n=2), osteosynthesis for talus fracture (n=2) and several other surgical procedures.

Complications (Table 2) occurred in 41% (n=46/113). The complication rate was higher in the patients with 2 screws (n=37; 48%) than in the patients with 3 screws implanted (n=9; 25%; p=.02). A total of 35 (31%) patients underwent subsequent revision surgery, accounting for 38% (n=29/77) of the cohort with 2 screws implanted and 17% (n=6/36) in the group with 3 screws implanted. The number of used screws also had a significant influence on the rate of revision surgery (p=.029).

A significantly higher incidence of non-union was found in patients with 2 (35%; n=27/77) when compared to patients with 3 screws implanted (14%; n=5/36; p=.025). The rate of revision arthrodesis was significant higher if 2 screws were implanted (31%; n=24/77) compared to 3 screws (11%; n=4/36; p=.034). The subgroup analysis revealed that in the patients with prior surgery of foot and ankle (n=58), the rate of revision

arthrodesis was higher (p=,034) in the group with two screws (19%; n=15/39) than in the group with 3 screws (n=2/19; p=,034). In the patients with prior ankle fusion (n=13), the incidence of revision arthrodesis was higher in the cohort of the patients with 2 screws, as 7 out of 8 patients underwent revision arthrodesis, whereas no patient underwent revision arthrodesis in the cohort of the patients with 3 screws (n=5; p=.005).

The necessity of implant removal was significantly higher in the patients with 2 implanted screws, as 5 patients (14%) following subtalar fusion using 3 screws and 31 patients (40%) following fusion with 2 screws underwent implant removal later on (p=.005).

Incidence of revision arthrodesis increased with patient age (p=.035). Median age was 53 (IQR, 43-57) in the patients undergoing revision arthrodesis (n=28), and 45 (IQR,35-52) in the patients without revision arthrodesis (n=85). A BMI $\geq$30kg/m^2 led to a significantly increased rate of revision arthrodesis (p=.04; OR,2.6; 95%CI, 1.1-6.3). Of the patients with a BMI $\geq$30kg/m^2, 37% (n=15/41) underwent subsequent revision arthrodesis, whereas only in 18% (n=13/72) of the patients with a BMI<30kg/m^2 required surgical revision. Smoking had no significant influence on re-arthrodesis (p=1). Diabetes mellitus was found to be associated with future revision arthrodesis, as 56% (n=5/9) of the patients with diabetes and 22% (n=23/104) of the patients without diabetes underwent revision later on (p=.04; OR,4.9; 95%CI, 1.1-17.8). Although prior surgery of the foot and ankle had no significant influence on the rate of revision arthrodesis (p=.34), prior ankle fusion was found to be a risk factor for future revision arthrodesis. The number of revised patients was as high as 7 out of 13 with prior ankle fusion, compared to the lower revision arthrodesis rate in the patients without prior ankle fusion, where number of revision arthrodesis was only 21% (n=10/45; p=.017; OR,4.4; 95%CI,1.3-14.5). Results of logistic regression analysis for significant risk factors was unable to detect independent risk factors.

DISCUSSION

To our best of knowledge, this is the first study to investigate the clinical differences between subtalar fusion with 2 and 3 screws. The implantation of a third screw for additional rotation stiffness and compressive force[12,13] comes with an increase of operation time, additional implant costs and a more extensive approach. The overall complication rate of this study (41%) was high compared to other studies. These findings can most likely be explained by the fact that even minor complications were included, such as wound healing disorders without revision surgery, adjacent joint osteoarthritis and even fibula fracture as relevant complications. When subtracting the above mentioned factors, revision rate drops to 32%, which is in line with rates reported by other authors[9]. The data of this study confirms the clinical relevance of the in vitro findings of Matsumoto et. al.[12] and Riedl et. al.[13], as the implantation of a third screw led to a significant decrease of non-union (p=.025) and lower rate of revision arthrodesis (p=.034). Consequently, overall complication rate was significantly lower (p=.02) in the patients with 3 screws implanted. Our findings suggest that the more extensive approach that is necessary for the implantation of a third screw, seems not to increase the rate of wound healing disorders or other complications (Table 2). Interestingly, additionally implanting a third screw did not increase the necessity of implant removal later on either.

The rate of non-union was 28% in both groups combined, with 35% in the group with 2 screws and 14% in the group with 3 screws. When compared to literature the rate of non-union, especially in the group with two screws, was higher than in most other trials[7,11,15–18] and only few trials reported a higher non-union rate[9]. However some high quality trials excluded patients with severe medical conditions, relevant hindfoot deformity or chronic conditions[11,16,17].

Many risk factors for non-union have been reported in literature such as elevated BMI[7,11], smoking[11], diabetes mellitus[11], prior foot & ankle surgery[7], and prior ankle fusion[14]. We noticed a higher incidence of revision arthrodesis in patients with higher age (p=.035). In accordance with existing literature[7,11] we also found obesity, defined as a BMI≥30 kg/m^2(p=.04, OR=2.6), and diabetes mellitus (p=.04, OR=4.9, 95%CI:1.1-17.8) to be relevant risk-factors for revision arthrodesis (p=.04, OR=2.6). However, smoking and prior surgery of the foot & ankle were not identified as risk-factors for the necessity of revision-arthrodesis later on in our study cohort. Of notice, the distribution of risk factors are highly heterogenous between different studies[9].

Screw placement of choice for the two posteriorly placed screws was parallel to apply more compressive force. It has been shown that diverging screws can increase torsional stiffness.[19] However, clinical relevance of this technique or biomechanical superiority to the placement of 3 screws has not yet been proven.

Major limitations of this study are the retrospective study design and the heterogeneous follow-up. To ensure that the patients with a short follow up (<12months) do not bias the study outcome (due to absence of revision surgery or non-union after 12 months), they were excluded from statistical analysis (n=18). Surgeries were performed by different surgeons and also, the indication for 3-screw-arthrodesis was made based on the surgeon's preference and therefore randomly distributed between patients. A further limitation is the radiological assessment, as it was carried out by a single viewer, primarily on lateral conventional radiographs of the foot. Despite the fact that evaluation of consolidation on lateral radiographs has been reported to be unreliable when compared to CT-scans[20], all the patients with residual pain or suspected non-union routinely underwent additional computed tomography of the hindfoot, which is the gold-standard for the evaluation of bony fusion and where a definitive conclusion concerning bony

consolidation could be reached . However, revision arthrodesis might be the most reliable end-point of our study and was therefore applied as the end-point for all risk factor.

The findings of this study strongly encourage the use of 3 screws for subtalar fusion. It is associated with a lower rate of overall complications, non-union, necessity of revision arthrodesis and implant removal. However, high quality randomized controlled trials will be necessary to confirm these findings.

Conclusion

Our findings suggest that successful subtalar fusion is more reliably achieved with use of three instead of two screws. Prior ankle fusion was identified as a significant risk factor for failure of subtalar fusion, which might be prevented by implantation of 3 screws. Although these results strongly favor the use of three screws, future prospective studies will be necessary to further specify the recommendation for use of three screws.

Conflict of interest statement

Dear Prof. Martinus Richter:

The manuscript “How Many Screws are Necessary for Subtalar Fusion? A Retrospective Study” by Stephan H. Wirth, Arnd Viehöfer, Yannik Fritz, Stefan M. Zimmermann, Dominic Rigling, and Lukas Urbanschitz is being submitted for publication in the journal “*Foot and Ankle Surgery”*.

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Therefore, there a no conflicts of interests for the authors, their immediate families, and

any research foundation with which they are affiliated, including receiving royalties, stock or stock options, consultant agreements, or ownership from or with any commercial entity related to the subject of this work.

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Image 1: different surgical techniques for subtalar fusion.

(A) 46-year old female patient with subtalar fusion for talocalcaneal coalition using 2 screws.

(B) 44-year old female patient with subtalar fusion for the treatment of fibrous coalition using 3 screws.

Table 1: Patients characteristics

Patients	2 Screws	3 Screws	Total	p
n	77 (68%)	36 (32%)	113	
Age	44±15	49±13	46±14	0.14
BMI	28±5	27±6	28±6	0.51
BMI >30	29 (38%)	12 (33%)	41(36%)	0.68
Smoker (active)	23(30%)	19 (53%)	42 (37%)	0.02
Diabetes mellitus	6 (8%)	3 (8%)	9 (8%)	1
Prior ankle fusion	8 (10%)	5 (14%)	13 (12%)	0.75
Prior ankle surgery	39 (51%)	19 (53%)	58 (51%)	0.84
Mean Follow up (m)	35	25	32	0.09
Indication				
Posttraumatic	36 (47%)	20 (55%)	56 (50%)	0.42
Primary osteoarthritis	32 (41%)	10 (28%)	42 (37%)	0.2
Tarsal coalition	7 (9%)	6 (17%)	12 (12%)	0.34
Postinfectious	2(3%)	0	2 (2%)	1

Complications	2 Screws	3 Screws	All
Non-union	27(35%)	5 (14%)	32 (28%)
Wound healing disorder	6(8%)	0	6 (5%)
Adjacent joint osteoarthritis	2 (3%)	2 (6%)	4 (4%)
Complex regional pain syndrome	1 (1%)	1 (3%)	2 (2%)
Fibula fracture	1 (1%)	0	1 (1%)
Sural nerve injury	2 (3%)	0	2 (2%)
Implant misplacement	2 (3%)	0	2 (2%)

Table 2: Complications after subtalar fusion